3PC: The Third Fermi-LAT Catalog of Gamma-Ray Pulsars

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We present 294 pulsars found in GeV data from the Large Area Telescope (LAT) on the Fermi Gamma-ray Space Telescope. Another 33 millisecond pulsars (MSPs) discovered in deep radio searches of LAT sources will likely reveal pulsations once phase-connected rotation ephemerides are achieved. A further dozen optical and/or X-ray binary systems co-located with LAT sources also likely harbor gamma-ray MSPs. This catalog thus reports roughly 340 gamma-ray pulsars and candidates, 10% of all known pulsars, compared to ≤11 known before Fermi. Half of the gamma-ray pulsars are young. Of these, the half that are undetected in radio have a broader Galactic latitude distribution than the young radio-loud pulsars. The others are MSPs, with six undetected in radio. Overall, ≥236 are bright enough above 50 MeV to fit the pulse profile, the energy spectrum, or both. For the common two-peaked profiles, the gamma-ray peak closest to the magnetic pole crossing generally has a softer spectrum. The spectral energy distributions tend to narrow as the spindown power $\dot{E}$ decreases to its observed minimum near 10^{33} erg s^{-1}, approaching the shape for synchrotron radiation from monoenergetic electrons. We calculate gamma-ray luminosities when distances are available. Our all-sky gamma-ray sensitivity map is useful for population syntheses. The electronic catalog version provides gamma-ray pulsar ephemerides, properties, and fit results to guide and be compared with modeling results.

History of Gamma-Ray Pulsar Catalogs

At the end of the Compton Gamma-ray Observatory (CGRO) era, there were 7 confirmed gamma-ray pulsars, plus 3 lower-significance candidates (1 of which was an MSP). In a series of three catalogs, the Fermi LAT has vastly increased this population to over 300, with about half of the known gamma-ray pulsars being MSPs, and about half of the young gamma-ray pulsars being radio quiet (RQ).

	Total #	MSPs	RL Young	RQ Young
EGRET/COMPTEL	7 + (3)	0 + (1)	7 + (2)	1
1PC	46	8	22	16
2PC	117	40	42	35
3PC	294	144	80	70

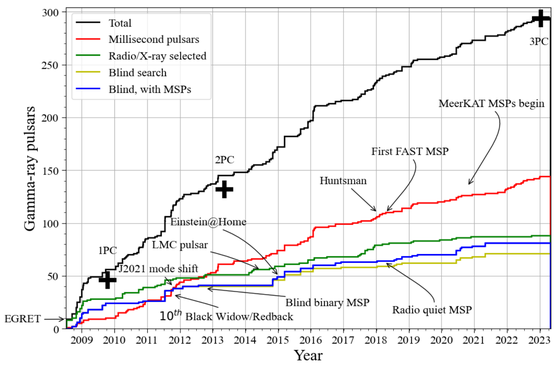
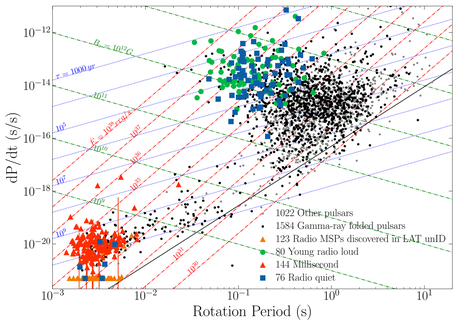
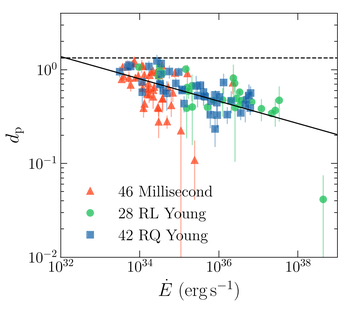


Table 1
Pulsar Varieties

Category	Count	Subcount
Known rotation-powered pulsars (RPPs)[a]	3436	
with measured $\dot{E} > 3 \times 10^{33}$ erg s^{-1}		762
MSPs ($P < 30$ ms)	681	
with measured $\dot{E} > 3 \times 10^{33}$ erg s^{-1}		250
Field MSPs[b]		427
MSPs in globular clusters[c]		254
Gamma-ray pulsars in this catalog[d]	294	
Spectral fits (with free b parameter)[f]		255 (116)
Profile fits in ⩾1, 2, 6 energy bands		236, 167, 28
Young gamma-ray pulsars	150	
Radio-quiet[e]		70
Gamma-ray MSPs	144	
Isolated, Binary		32, 112
Discovered in LAT blind searches		10
Radio-quiet		6
Black Widows, Redbacks:		32, 13
Radio MSPs discovered in LAT sources	119	
with gamma-ray pulsations		78
waiting for ephemeris phase-connection[d]		33





Left: *P-Ṗ* plot showing the LAT gamma-ray pulsars in the context of the broader pulsar population. **Right**: Plot of the spectral peak curvature (d_p), vs $\dot{E}$, showing a well-defined trend.

References

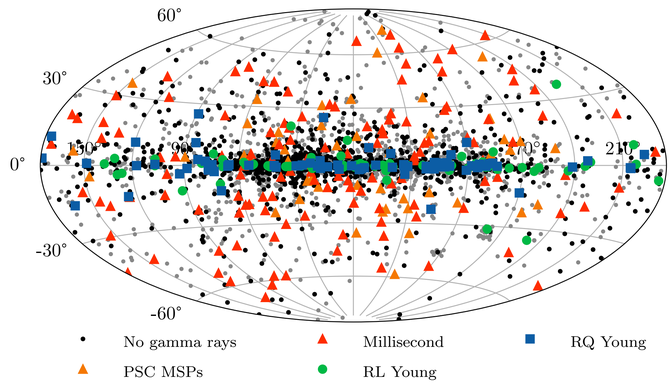
(CGRO) D. J. Thompson (2004) , Astrophys. Space Sci. Lib. 304, Cosmic Gamma-Ray Sources, 149

(1PC) A. A. Abdo, et al. (2010), ApJS 187, 460

(2PC) A. A. Abdo, et al. (2013), ApJS 208, 17

(3PC) D. A. Smith, et al. (2023), ApJ 958, 191

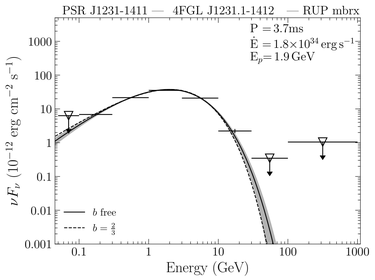
3PC Sky Map

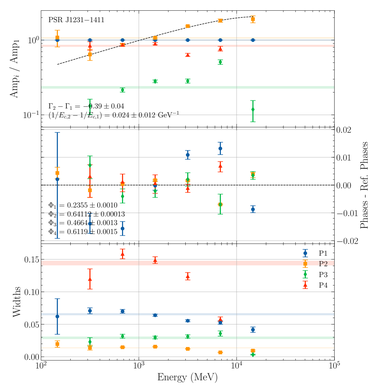


Some Key Results

- Gamma-ray efficiency tends to decrease as $\dot{E}^{-1/2}$ but with substantial scatter, and essentially all gamma ray pulsars have (Shklovskii-corrected) $\dot{E}$ above the "deathline" at 10^{33} erg/s.
- Gamma-ray fluxes and radio fluxes are essentially uncorrelated, so newer and deeper radio searches will continue to uncover new gamma-ray pulsars.
- The LAT catalog will probably reach 400 pulsars in the coming years, but will probably not double in size.
- Pulsar spectral energy distributions (SEDs) are characterized by their peak energy (E_p) and the spectral curvature at the peak (d_p, where higher means more sharply peaked). Both are inversely correlated with $\dot{E}$. As a consequence, pulsars emit most of their power in the 0.1–10 GeV band, with sharply-peaked MSPs concentrated in the higher decade.
- The majority of pulsars have two principal peaks separated by Δ≈0.4±0.15 rotations, and for radio-detected pulsars the first gamma-ray peak generally trails the radio pulse by δ≈0.2±0.2 in phase.
- There is a weak trend where pulsars with closely spaced primary peaks in the pulse profile tend to have the highest SED peak energies.

Data Products





Data products from the catalog are available online at the Fermi Science Support Center (FSSC):

https://fermi.gsfc.nasa.gov/ssc/data/access/lat/3rd_PSR_catalog/

You can find:

- HTML pages (1 per pulsar) with basic info, pulse profiles, SEDs, timing models, and links to the FT1 phased event data files
- The catalog file in FITS and Excel format, with example python scripts
- All timing models (.par files) used for the catalog
- All-sky sensitivity map
- SED plots for all pulsars (example in upper left)
- Pulse profile plots (example at right) and energy-resolved profile fits (example at lower left)
- Information on pulsars found since 3PC was published

Also, note that the catalog is included as a data overlay on the Fermi LAT Light Curve Repository as well:

https://fermi.gsfc.nasa.gov/ssc/data/access/lat/LightCurveRepository/